

Remarks

This Preliminary Amendment cancels without prejudice original claims 1-12 in the underlying PCT Application No. PCT/EP2004/051820 and adds new claims 13-24. The new claims conform to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.125(b), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121(b)(3)(ii) and § 1.125(c), a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/EP2004/051820 includes an International Search Report, dated November 17, 2004. The Search Report includes a list of documents that were uncovered in the underlying PCT Application.

Applicants assert that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

KENYON & KENYON LLP

 (P. NO. 36,197)

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By: SONG LEE for Gerard Messina
Gerard A. Messina
(Reg. No. 35,952)
One Broadway, NY, NY 10004
(212) 425-7200
CUSTOMER NO. 26646

FUEL INJECTOR

~~Background Information~~ Field Of The Invention

The present invention ~~is based on~~ relates to a fuel injector of the type ~~set forth in the main claim~~ for direct injection of fuel, which fuel injector is provided with a seal.

5 Background Information

~~From~~ Published European patent document EP 0 828 075 A1, ~~for example,~~ describes a fuel injector for the direct injection of fuel into the combustion chamber of an internal combustion engine ~~is known~~, which has a device for adjusting the temperature in the region of
10 the valve tip so as to reduce deposits in this area. The device is embodied in the form of a coating made of a thermally conductive material on the valve tip.

~~Disadvantageous in~~ Disadvantages of the fuel injector ~~known from~~ described in the European patent document EP 0 828 075 A1 are
15 the high demands regarding the accuracy of fit of the components and the complicated installation, which is involved and thus cost-intensive.

Furthermore, a fuel injector for the direct injection of fuel into the combustion chamber of a mixture-compressing internal
20 combustion engine having external ignition is ~~known from~~ described in published German patent document DE 101 09 407 A1. It includes a valve housing formed by a nozzle body, and a sealing ring which seals the fuel injector from a cylinder head of the internal combustion engine. The sealing ring has a convexly arched profile,
25 the two ends of the sealing ring axially overlapping in the form of a step.

Particularly disadvantageous in the fuel injector known
~~from~~ described in published German patent document DE 101 09 407
A1 is the air gap between the fuel injector and the cylinder head,
which allows an only limited heat transfer. This is disadvantageous
5 in reducing deposits on the valve tip since the temperature in the
region of the spray-discharge orifices must be as low as possible
so as to avoid deposits.

~~Summary of the Invention~~ Summary

In contrast, the fuel injector according to the present invention,
10 ~~having the characterizing features of the main claim,~~ has the
advantage that a seal is situated between the cylinder head and
the nozzle body, the seal extending over the entire axial length
and having a suitable structure, thereby providing not only a
reliable sealing effect but effective heat dissipation away from
15 the nozzle body as well.

~~Advantageous further developments of the fuel injector specified
in the main claim are rendered possible by the measures delineated
in the dependent claims.~~

It is particularly advantageous that any desired cross sections
20 are possible, ~~for instance~~ e.g., corrugated tubes, convoluted
bellows, and smooth tubular bodies having protuberances formed in
a variety of shapes.

In an advantageous manner the seal may also be made up of a plurality
of layers, which gives it higher stability and makes it less likely
25 to be damaged during the installation.

In addition, it is advantageous that a cover plate, which functions
as heat shield, may be situated on a discharge-side end of the seal.
The cover plate may have an opening for the spray-discharged fuel
jets or it may have a plurality of spray-discharge openings.

30 The seal ~~is advantageously~~ may be produced from a metallic material
having an amorphous structure, so that a smooth surface is able
to be achieved.

~~Brief Description of the Drawing~~

~~Exemplary embodiments of the present invention are shown in a simplified version in the drawing and elucidated in greater detail in the following description.~~

5 ~~The figures show:~~ Brief Description of the Drawings

Fig. 1 shows a ~~A schematic section~~ cross-sectional view through a conventional fuel injector ~~according to the related art,~~ .

Fig. 2 shows a ~~A schematic, part sectional~~ cross-sectional view of a first ~~exemplary~~ example embodiment of a fuel injector according
10 to the present invention~~,~~ .

Fig. 3 shows a ~~A schematic, part sectional~~ cross-sectional view of a second ~~exemplary~~ example embodiment of a fuel injector according to the present invention~~,~~ .

Fig. 4 shows a ~~A schematic, part sectional~~ cross-sectional view of a third ~~exemplary~~ example embodiment of a fuel injector according
15 to the present invention~~,~~ .

Fig. 5 shows a ~~A schematic, part sectional~~ cross-sectional view of a fourth ~~exemplary~~ example embodiment of a fuel injector according to the present invention~~,~~ .

Fig. 6 shows a ~~A schematic, part sectional~~ cross-sectional view of a fifth ~~exemplary~~ example embodiment of a fuel injector according
20 to the present invention~~,~~ and.

Fig. 7 shows a ~~A schematic, part sectional~~ cross-sectional view of a sixth ~~exemplary~~ example embodiment of a fuel injector according
25 to the present invention.

~~Description of the Exemplary Embodiments~~ Detailed Description

Before ~~preferred~~ exemplary example embodiments of a fuel injector
1 according to the present invention are described in greater

detail ~~with the aid of~~ in connection with Figures 2 through 7, for a better understanding of the present invention, a conventional fuel injector 1 ~~according to the related art shall first~~will be briefly explained in terms of its essential components on the basis
5 of Figure 1.

Fuel injector 1 is configured ~~in the form of a fuel injector for~~ fuel-injection systems of mixture-compressing internal combustion engines with externally supplied ignition. Fuel injector 1 is suited, ~~in particulare.g.,~~ for the direct injection of fuel into
10 a combustion chamber 2 of an internal combustion engine.

Fuel injector 1 includes a nozzle body 3, which is sealed from a cylinder head 5 of the internal combustion engine by a sealing ring 4. Sealing ring 4 is made of, for instance, an elastomeric material such as a Teflon-coated material and provides the sealing effect
15 in cylinder head 5 as a result of a slightly larger diameter compared to nozzle body 3.

Furthermore, fuel injector 1 includes a housing 6, an electric plug-in contact 7 for actuating fuel injector 1, and a fuel feed 8, via which the fuel is conveyed. Fuel may be supplied via a
20 fuel-distributor line, for example, which is not shown further.

~~Disadvantageous in~~Disadvantages of the sealing rings 4 ~~known from the related art~~conventional configuration is, in particular, the poor heat transfer between nozzle body 3 and cylinder head 5 because of an air gap 9 on the discharge side between fuel injector
25 1 and cylinder head 5. In order to counter the threat of coking of the spray-discharge orifices of directly-injecting fuel injectors 1 as a result of the high temperatures in combustion chamber 2, the lowest possible temperature is to be desired in the region of the valve tip. This ~~counteracts~~prevents a complete
30 evaporation of the fuel remaining in the region of the valve tip after the injection process. If the fuel remains liquid, the combustion residue and impurities are unable to deposit in the

region of the valve tip and are carried away during the next injection cycle.

The poor heat transfer between fuel injector 1 and cylinder head 5 in the conventional configuration is counteracted by a seal 10 configured according to the present invention, as illustrated ~~in~~ by preferred exemplary example embodiments shown in Figures 2 through 7.

Seals 10 described below all have in common the fact that they are designed as corrugated tubes and thus not only provide excellent sealing action but also offer a sufficiently large contact surface for an effective heat transfer between fuel injector 1 and cylinder head 5. Seals 10 are designed in such a way that they are short and broad in the non-installed state ~~and, but~~ are pressed together slightly by the installation and become longer as a result. This makes it possible to achieve an excellent fit.

Seals 10 are made of a material that exhibits great thermal conductivity ~~such as, e.g.,~~ a metal foil having an amorphous structure, so that it is possible to achieve a very smooth surface with the advantage of a simple and damage-free installation.

Cavities 16 formed between fuel injector 1 and seal 10 by the different cross-sectional forms may be used for passing through a coolant.

In the following, ~~exemplary example~~ embodiments for fuel injectors 1 provided with corresponding seals 10 will be described ~~by way of example~~. With the exception of the inventive measures provided according to the present invention, fuel injectors 1 according to the present invention may be designed similar to the conventional fuel injector 1 ~~illustrated~~ in Figure 1.

Figure 2 shows a first ~~exemplary example~~ embodiment of a fuel injector 1 configured according to the present invention. Here, in the simplest manner, seal 10 has the form of a corrugated tube.

Seal 10 is open at both sides and is thus able to be mounted in an especially uncomplicated manner. Seal 10 may be premounted on nozzle body 3 of fuel injector 1 and then inserted into cylinder head 5 together with it.

5 Figure 3 shows a second ~~exemplary~~example embodiment of a fuel injector 1 configured according to the present invention. In this ~~exemplary~~example embodiment, seal 10 has the form of a tubular seal 10 having protrusions 11. Protrusions 11 are approximately
10 semicircular in section. The advantage of this ~~variant~~embodiment is a slightly larger contact surface on nozzle body 3 resulting in improved thermal conductivity.

Figure 4 shows a third ~~exemplary~~example embodiment of a fuel injector 1 configured according to the present invention. In this case seal 10 has a pleated design and has been formed into expansion
15 bellows 10. The thermal conductivity and sealing ability correspond approximately to that of the first ~~exemplary~~example embodiment described in Figure 2.

Figure 5 shows a fourth ~~exemplary~~example embodiment of a fuel injector 1 configured according to the present invention. Here,
20 seal 10 is made up of a plurality of layers 12 in a sandwich-like manner. This increases the durability of seal 10, in particular, which is unable to deform as easily during installation and thus is less likely to be damaged. The individual layers 12 may in turn be designed in the form of a corrugated tube and be bonded to each
25 other, or they may be joined to each other only at their ends.

Figure 6 shows a fifth ~~exemplary~~example embodiment of a fuel injector 1 configured according to the present invention. Here, seal 10 may have the same cross-sectional design as seals 10 according to the ~~exemplary~~example embodiments illustrated in
30 Figures 2 through 5, the corrugated tube design having been chosen in Figure 6. In addition, on a discharge-side end 13, it is provided with a cover plate 14 which has an opening 15 for the fuel jets

injected into combustion chamber 2 from at least one
spray-discharge orifice of fuel injector 1. Cover plate 14
additionally has the function of a heat shield and protects the
spray-discharge orifices from the high temperature prevailing in
the combustion chamber, the high temperatures increasing the
coking tendency of the spray-discharge orifices.

Figure 7 shows a sixth ~~exemplary~~example embodiment of a fuel
injector 1 configured according to the present invention. Here,
as in the ~~exemplary~~example embodiment shown in Figure 6, seal 10
may have the same sectional design as seals 10 illustrated in
Figures 2 through 5, the corrugated tube design having been chosen
in Figure 7 as well. Seal 10, ~~too,~~ has a cover plate 14 on a
discharge-side end 13, into which the spray-discharge orifices may
be worked directly. Cover plate 14 also assumes the function of
a heat shield and protects the discharge-side end of fuel injector
1 from the temperature prevailing in the combustion chamber.

The present invention is not restricted to the ~~exemplary~~example
embodiments shown, but is also applicable to other cross-sectional
forms of seals 10, as well as to a wide variety of construction
types of fuel injectors 1, such as fuel injectors 1 having an
interface to an intake manifold or a common-rail system.

In ~~particular~~addition, the individual features of the various
~~exemplary~~example embodiments may be combined with each other as
desired.

~~Abstract~~

ABSTRACT

A fuel injector ~~(1)~~, ~~in particular~~ for the direct injection of fuel into the combustion chamber of a mixture-compressing internal combustion engine having external ignition, includes a valve housing formed by a nozzle body ~~(3)~~, and a seal ~~(10)~~ which seals the fuel injector ~~(1)~~ from a cylinder head ~~(5)~~ of the internal combustion engine. The seal ~~(10)~~ has a sleeve-type design with a structured cross section and extends across the axial length of the nozzle body ~~(3)~~.

10 ~~(Fig. 2)~~